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COLOUR-BLINDNESS

Colour-Blindness, its Dangers, and its Detection. By B. Joy Jeffries, A.M., M.D., Ophthalmic Surgeon. (Boston, America: 1879.)

SOME months ago the subject of colour-blindness was introduced into the columns of this periodical as bearing on a question of colour nomenclature. Little was then said on the subject itself beyond what was necessary to illustrate the point in dispute, but it may now be added that the general features of this remarkable defect of vision have lately been exciting much attention, and have given rise within the last few years to a somewhat extensive literature, involving points on which there has been much difference of opinion and some energetic controversy.

It is just a century since the first public announcement was made, through Dr. Priestley, of a case of defective vision, which, by the account left on record, we can easily recognise as being of the kind subsequently found so common. About twenty years later we come on the well known and often-quoted description of his own case, given by John Dalton, which, after another lapse of thirty years, was commented on by Sir John Herschel in a very lucid and instructive manner. This celebrated case has given rise to the name "Daltonism," by which the complaint is most generally designated by Continental writers, but which has been objected to by the English, on the ground that it is no compliment to their great chemist to associate his name with an unfortunate natural defect in his optical apparatus. Many other words, chiefly derived from the Greek, have been from time to time proposed, but the simple term *colour-blindness,* adopted generally by English writers, and its equivalent, *Farbenblindheit,* used by the Germans, appear to answer every purpose, and to be unobjectionable. For, whatever may be the special characteristics of the defect (and on this point there are differences of opinion), it is admitted on all hands that an inability to appreciate the sensation conveyed by some particular colour or colours to the normal eye must be its most distinguishing feature.

In 1840 appeared an essay by Prof. Elie Wartmann, of Lausanne; but the first complete work on the subject was the "Researches on Colour-Blindness," by Dr. George Wilson, of Edinburgh, published in 1855. After this several memoirs are to be found, chiefly in transactions or journals; but the subject attracted little notice beyond mere curiosity, till a few years ago, when oculists and physiologists suddenly woke up to a conviction that it had a real importance, both theoretical and practical, and therefore deserved more careful study than it had yet received. This movement appears to have originated in a more vivid appreciation of certain dangers that were considered likely to arise from the employment, in railway and marine service, of persons who were colour-blind, and were consequently liable to mistake coloured signals. This danger had been clearly pointed out by Prof. Wilson, but it had required many years for its importance to become recognised. When, however, attention was roused, there was no lack of persons ready to undertake the investigation of the subject, and a host of works have appeared by many men of eminence proposing means of providing against the evil; and although the inquiries have been instituted at first with chiefly a practical bearing, they have naturally, in the hands of scientific men, been mixed up with a good deal of speculation of a more theoretical kind. Among the workers who have busied themselves with the subject may be mentioned Prof. Holmgren, of Upsala, in Sweden; Dr. Stilling, oculist at Cassel; Dr. Magnus and Prof. Cohn, of Breslau; Prof. Donders, of Utrecht; Prof. Ewald Hering, of Prague; Dr. Daae, of Norway; Drs. de Wecker and Landolt, of Paris; and Professors Delbœuf and Spring, of Liege. Unfortunately, although we know that some of our most eminent oculists in England have also lately had the subject under their consideration, their researches have not yet been made public, and it is, therefore, opportune that we are able to announce the appearance of a work which, although not by an Englishman, is in our language, and will, therefore, make the English reading public acquainted with what has been done.

The author is ophthalmic surgeon to several hospitals; he is otherwise much connected with ophthalmological matters, and has had large experience in regard to colour-blindness. He gives a good and full account of the general nature and statistics of the defect, and the means he considers best calculated for its detection; enlarging on the necessity for a systematic testing of the vision of servants on railways and sea-going vessels, and recommending the rigid exclusion of those who have imperfect colour-vision. He further devotes some attention to matters of theory, adopting and advocating the views most generally entertained.

It is impossible, in the short space of such a notice as the present, to give any extended analysis of the recent comprehensive investigations; it must suffice to make a few remarks on some of the more prominent points of interest; and first as to the statistics. Dr. Jeffries has some interesting chapters on this head, and states that variable statistics have been given by different observers, depending largely on the mode of testing.

In regard to males, he gives a table of the results obtained by eleven different observers, who had examined on the aggregate about 50,000 persons, chiefly pupils in schools, *employés* on railways, soldiers, or sailors. The proportion of colour-blind persons was given variously from 3 to 6 per cent., the average being about 4. Assuming, therefore, the examinees to represent fairly the general population, we may take it for granted that one out of every twenty-five men we meet is deficient of any true ideas respecting the colours of objects he sees around him.

With females, the case is very different, the defect in that sex being exceedingly rare. Out of nearly 20,000 women and girls examined, there were only registered forty cases of colour-blindness, or 0·2 per cent.; and some of these are of doubtful accuracy. This is a very singular fact, for which no sufficient explanation has ever been suggested; it has indeed been remarked that women devote much more attention than men to colours in general, but this has no bearing on the question, inasmuch as the evil is not a functional derangement, which might be brought right by exercise, but a natural and congenital defect of organic structure, altogether incapable of cure or even amelioration by any means at present known.

There is every reason to believe the defect is hereditary, and Dr. Jeffries gives some data as to its transmission, showing the curious law (not, however, without exceptions) that it is transmitted *through* the females, although the females themselves escape it, thus skipping over every other generation. For example, if a man is colour-blind he will have no colour-blind children, neither will any of his sons' sons be colour-blind, but the defect will probably be found among the sons of his daughters.

It has been asserted by some authorities that a higher percentage of cases exists among people of the Jewish faith, and an ingenious question has been raised whether this may not indicate a descent from an early general type of imperfect vision, so giving a sort of support to the Gladstonian theory of development of the colour-sense. But as the fact is disputed, it is useless to trouble ourselves about any inference from it.

Another point of interest is the mode of testing and examining the colour-blind, and a large portion of Dr Jeffries', as of all other late works, is devoted to this matter. There are two distinct objects in view in such examinations: first, simply to discover whether the examinee is or is not colour-blind; secondly to find out the precise nature of his sensations of colour.

The first is of the more practical importance, and it is aimed, of course, chiefly at the testing of railway servants and others who have to do with colours. I hold a strong opinion that too much alarm has been created about the danger of mistaking railway signals. Normal-eyed people (who have always the greatest difficulty in comprehending what the colour-blind really see) generally believe that because under certain circumstances a red and a green object give similar impressions to a Daltonian, therefore he must, under all circumstances, confound redness and greenness. Nothing can be further from the truth, and I may give my own experience with railway signals as an example. I have had a great deal to do with railways, and although there can be no doubt about my colour-blindness, I do not recollect that I ever experienced any difficulty in distinguishing a red lamp from a green one. They are always strongly contrasted to my eye, and often, when I have passed at night through Cannon Street Station, I have amused myself by watching the changes in the imposing array of signals exhibited there. I could give a sufficient explanation of this, but it would be out of place here. I believe, so far as my knowledge at present goes, that nearly all colour-blind patients see the distinction as well as I do; and this view is corroborated by the great fact that, although we may assume that down to a late period about one out of every twenty-five engine-drivers has been colour-blind, never since railways have been in use has a single accident occurred which has been positively attributable to the mistaking of a red for a green night signal. If the notions of the alarmists were well founded, we should have had collisions every day. At the same time I do not deny the possibility of danger, under certain circumstances, and I would by no means discourage the precautions proposed in the selection of men.

It is not so easy a matter to identify positively a case of colour-blindness as might at first be supposed. Mere inaccuracy in naming colours is not sufficient, for it often happens, on the one hand, that normal-eyed people name colours incorrectly, and, on the other hand, that colour-blind people will name many colours correctly. There have been several kinds of tests adopted by different examiners, but the most important are those by Holmgren, Schilling, and Daae. The first is the one recommended by Dr. Jeffries, and it is described by him at considerable length. The test is made with a large number of samples of worsted (or what we call Berlin-wool) of a great variety of colours and shades. A certain sample, of a pale but decided tint of green, is shown to the patient, who is desired to select from the heap all the specimens which, to his eye, match it in colour. If he is normal-eyed he will select only green samples, but if he is colour-blind he will add others of other colours, such as pink, light-brown, gray, &c., which, though so different to the normal-eyed, match the green tint to his defective vision. But the wools have to be carefully selected, and are expensive. Dr. Schilling's test consists of a set of lithographed coloured diagrams; he takes two colours which, though normally strongly contrasted, he knows appear alike to the colour-blind, say scarlet and yellow-brown, and he draws letters or patterns in one of these, on a ground of the other, *i.e.*, a scarlet pattern on a brown ground, or *vice versâ*, the design being so ingeniously arranged as to avoid betraying any lines of division. A single glance at these diagrams by a colour-blind person suffices to test his vision. If he is normal-eyed the patterns are visible to him; if he is colour-blind they are invisible, the whole diagram conveying to his mind the idea of one uniform colour.

Dr. Daae's test is a little page of samples of coloured worsted, arranged in rows. Some of the rows are devoted each to one colour, arranged in different tints and shades, while other rows contain different colours in the same row. If the patient is unable to distinguish between these two classes he is colour-blind.

All these tests are very simple, and appear to be efficient so far as the mere detection of the fact is concerned, which is all that is wanted for economic purposes.

But some of the investigators go farther; they prescribe other tests with a view to find out what is the nature of the patient's vision—to get an idea of what he actually sees. The arrangements proposed for this purpose are much more elaborate. Holmgren, for example, exhibits other samples of wool, and endeavours to infer the nature of the vision by observing what colours are considered to match it. Schilling has different sets of diagrams for what he considers different classes of the complaint, while many other contrivances, some of them extremely complicated, have been designed to test the vision by shadows, by coloured glasses, by reflected images; by polarisation, by contrast, by comparisons, and by the spectroscope. These are all more or less unsatisfactory, and the information hitherto obtained by them is worth very little. The answers of the patients are seldom trustworthy, and they are almost always interpreted by the examiner to suit some preconceived theory of his own. One of the most earnest and industrious investigators, Dr. Cohn, gives a long list of answers he has received, but he has unfortunately vitiated his whole work by relying to a large extent on the naming of colours by the patients. This is the very worst and most fallacious test of all, and Dr. Jeffries quotes, in reference to it, the following forcible remarks by Helmholtz :—

> "As to the examination of the colour-blind, simply asking them to name this or that colour will naturally elicit but very little, since they are then forced to apply the system of names adapted to normal perception to their own perception, for which it is not adapted. It is not only not adapted, because it contains too many names, but in the series of spectral colours *we* designate differences of tone [hue ?] as such, which to the colour-blind are only variations of saturation or luminosity."

My own experience enables me thoroughly to corroborate this : if any one asks me to name a colour shown me, I tell him it would be as reasonable to treat me as a clairvoyant and to expect me to read the contents of a sealed envelope.

But these inquiries, as above stated, always have to do with the *theories* of colour-blindness, and a few words must be said on this point, which is one of great difficulty, and in regard to which the state of knowledge is at present exceedingly unsatisfactory. When Dalton wrote what may be considered the first good account of the defect, he, notwithstanding his great acuteness and his extraordinary powers of scientific investigation, failed to discover the important point of his case, namely, that he saw *two colours only*—yellow and blue. This was found out for him at a much later period by the penetration of Sir David Brewster and Sir John Herschel, who designated the malady by the term, *dichromic vision*, which has ever since been used. Sir David Brewster, acting on this, framed a very simple explanation of the defect, founded on his own views as to the nature of colours. He had a theory that the solar spectrum was formed from three separate spectra overlapping each other, one giving red light, one yellow, and one blue, which might therefore be considered the three primitive colours for normal eyes, as it was taken for granted all other colours might be compounded from them. All that was necessary for the explanation of colour-blindness was to assume the eye of the patient insensible to the red rays, and the phenomena followed as a matter of course. This theory was a very plausible one, and is still in favour with many persons who have practically to do with colour. But unluckily on further examination it was found wanting, inasmuch as one of the main effects in it, namely, the supposed production of green by a mixture of yellow and blue, turned out to be a delusion ; and moreover, as the theory of light became better known, the idea of overlapping spectra was abandoned, it being clear that every hue of colour had its own peculiar generating wave. Hence Brewster's elegant and simple explanation of colour-blindness fell to the ground.

Some years afterwards came out what is called the "Young-Helmholtz" theory, which assumes that the normal visual organs are capable of being impressed with three colour sensations, corresponding to red, green, and violet, and that all colour-perception is caused by the combined action of these in varying proportions. It is then assumed that in colour-blind people one of these sensations is wanting, leaving only the other two in action, and thus causing dichromic vision. The most common defect is supposed to be blindness to red, and on this hypothesis the colour-blind ought to see only violet and green. At the same time the supporters of this theory fancy they can detect some cases where the green is wanting, leaving only red and violet, and others where the violet is wanting, leaving visible only the red and the green.

This theory is in great favour, owing to the eminence of its authors and the support of many distinguished physicists ; and it is adopted implicitly by Dr. Jeffries. But objections have been raised to it on several grounds, one of the most forcible being that it does not accord with the experience of the colour-blind. If there is any one fact more unequivocally deducible from their evidence than another, it is that the less refrangible colour they perceive corresponds to yellow, and not to green. In my own case, which I believe is a typical one, my long-wave colour is most vivid and positive, and it is an absolute certainty that its maximum splendour is excited by the buttercup, or by the pigment chrome-yellow, or by the sodium line ; whereas objects that I hear called green give me no definite impressions at all ; sometimes they assume a debased, dirty, or washed-out buttercup colour ; sometimes they look black or grey ; and sometimes they even give my opposite sensation, blue. How, therefore, it can be argued that my most brilliant buttercup sensation is excited by green objects rather than by yellow ones, is to me unintelligible.

A theory has lately been started by a Belgian *savant*, that the colour-blind defect is caused by an undue sensitiveness to green, which destroys the proper effect of other colours ; to illustrate which he says that the normal eye, by looking through a certain green solution, will become colour-blind. But he carries his theory to the further length of asserting that if a colour-blind person looks through a certain red solution, he will be restored to normal vision, a conclusion which is so improbable that we may dismiss the theory from consideration, particularly as it has found no supporters.

There is, however, another hypothesis lately offered, which has a very different aspect. It was laid before the Academy of Sciences of Vienna a few years ago by Herr Ewald Hering, Professor of Physiology at Prague. Its scope is considerably wider than has to do with our present purpose, as it embraces the whole physiological theory of the perception of light, and it would be out of the question to give a complete account of it here. It is, however, of such great importance, and has been so favourably received by some of the highest authorities, that it may be worth while to devote a future article in NATURE to its description. Meantime it may be briefly stated that the author assumes, not three fundamental colour-sensations, as in the Young-Helmholtz theory, but (excluding black and white, for which he provides separately) *four*, namely, blue, yellow, red, and green.[1]

These, however, result from only two sources of sensation, each of which is capable of a double, or reversible, mode of excitement (in a manner somewhat analogous to positive and negative in electricity, or plus and minus in algebra), producing the sensation of two colours complementary to each other. Thus, one of the sources of sensation corresponds to blue and yellow, the blue rays exciting it in one direction and the yellow rays in the other. The other source corresponds to red and green, and is excited in like manner. It will at once be seen with what admirable simplicity this will explain colour-blindness, avoiding the violence done to the evidence by the Young-Helmholtz doctrine. Normal-eyed persons possess both sources of sensation; colour-blind persons possess only one. The usual case is when the red-green source is absent, the patient seeing only blue and yellow; but the other defect is possible, giving blindness to blue and yellow, and vision only of red and green; and Dr. Stilling, who strongly espouses the theory, states that rare examples of this have been found. If both sources of sensation are absent, the patient sees only light and shade, and this case also is said to have been practically known.

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[1] In the description of my own case, published in the *Philosophical Transactions* for 1859, I ventured to express the view that the assumption of these four colours as fundamental, was necessary in order to explain satisfactorily the phenomena of colour-blindness.

It is a pity Dr. Jeffries has omitted to mention this theory, which, if it should be substantiated by further inquiry,[1] bids fair to be a most valuable contribution to our knowledge. In the meantime the phenomena of colour-blindness, from the important bearing they have on the nature of colour-perception generally, require much further careful investigation.

WILLIAM POLE

OUR BOOK SHELF

Elementary Lessons on Sound. By Dr. W. H. Stone, Lecturer on Physics at St. Thomas's Hospital. (London: Macmillan and Co., 1879.)

SINCE the publication, some five and twenty years ago, of Helmholtz's great work on musical acoustics, the study of the nature of sound has become popular. The ordinary phenomena of hearing must interest every one; but it is to the thoughtful student of music that the subject presents its chief attractions. We cannot imagine any intelligent musician who will not be desirous to know something of the foundation of the wonderful fabric he has to deal with, and to learn how the principles of science bear on the practice of the art.

It is well, therefore, that Messrs. Macmillan have included among their School Class Books one which gives, in a very small compass, a large amount of information as to the laws and phenomena of sound. The author has not only extracted the essence of what is contained in bulky and expensive treatises, sometimes in foreign languages, but he has also given much additional information from memoirs and transactions of scientific societies out of the reach of the ordinary public.

The application of acoustics to musical instruments is a useful addition, the subject being one which the author has made specially his own. He has also stated some of the simplest facts of the connection between acoustical phenomena and the structure of music; but this is too wide a subject, and involves far too complicated considerations to be fully dealt with in an elementary work of this kind.

We notice a few trifling errors, as, for example, on page 3, the monochord can hardly be said to be "named after" Pythagoras; and Tartini's *terzo suono* was intended by him rather as a guide to correct double-stopping than "tuning." On page 11, line 7, the expression "first partial" is probably meant to be "first overtone." On page 76 a pretty contrivance, by Mr. Francis Galton, is ascribed to Capt. Douglas Galton. These things are, however, of little consequence.

LETTERS TO THE EDITOR

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[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Local Colour-Variation in Lizards

THE interest which some notes by Messrs. Wallace and Giglioli (published in NATURE) have called forth with regard to the local variation of colour in reptiles causes me to publish these few lines.

Since the year 1874 I have been carefully studying this subject, and therefore wish to remove the generally prevailing opinion that no endeavours have yet been made to explain it. I have not thought it necessary to write this before, thinking that my works touching this subject were known to naturalists, or would have become known through the mention Mr. Carpenter makes of them. Such, however, is not the case. Neither English nor Italian zoologists have taken any notice of the newer German publications concerning the local variation of colour in lizards. They content themselves with merely mentioning many new and truly interesting instances of this variation, but leave unnoticed all attempts made to obtain an explanation of the same.

The first effort to explain this appearance was made by Mr. Eimer in 1872, at the time that the beautiful black and blue lizard was discovered on the Faraglioni rocks, near Capri. Prof. Eimer tries to explain this change of colour in the *Lacerta muralis* (which is green both on the Continent and the Island of Capri) by attributing it to an adaptation to the colour of the Faraglioni rocks. However, as those rocks are not of a bluish-black, but rather a yellowish-red colour, intermixed with a little gray, and as, moreover, the lizards there have no enemies against which they require protection, and therefore no adaptation is necessary, I considered Prof. Eimer's explanation a failure, and at the same time I tried to confirm by fresh facts my hypothesis made in 1874 ("Ueber die Entstehung der Farben bei den Eidechsen," Jena, 1874). This hypothesis, which, it is true, has till now met with little approval, is as follows:—The skin of the lizard has two layers of pigment. The black pigment, which lies lowest, gets the power, under the concentrated influence of the sun, to leave its motionless state, and is made to rise by the contraction which the nerves exercise on the cells containing it, and by forcing itself more or less upwards through the elements of the pale layer of pigment, gives us the impression of different colours. That change of colour which we are able to observe in chameleons in a short space of time, under the condition of a frequent change of light, takes place with lizards only in the course of ages, embodying itself in manifold degrees of development, and provided the animal does not change the locality, remains as a distinguishing characteristic of the form. If, however, the lizard changes its locality, if it is isolated on a rock or islet which has separated itself from the mainland, and is entirely and constantly exposed to the rays of the sun, as must naturally be the case on rocks which, like the Faraglioni or the Island of Ayre, are void of all vegetation, in that case, I say, the black layer of pigment is set in motion, and by constant successive risings to the surface at last gains a definite superposition over the yellow pigment, as has been the case with the black Faraglioni and Lilfordi lizards.

This phylogenetic development of colours can be traced (as I have already mentioned in the year 1874) by the individual development of colour in the lizard, but necessarily only under the constant strong influence of the sun on young individuals. Dr. Braun, in his work on the *Lacerta lilfordi*, informs us that the young lizard of the Island of Ayre has exactly the same colour as its typical form on the larger Balearic islands, and only turns black in the course of its growth.

Though we can only observe the turning black of these lizards in the individual growth of the animal, we can obtain a returning of the full-grown animals to their original paler colours by artificial means, that is, by preventing the rays of the sun from falling on them perpendicularly. By these means I completely discoloured numbers of the Faraglioni lizards and the brown ones from the island of Ponza. The former turned bluish-green, the latter brownish-green.

Before I pass on to an enumeration of the above-named trans-

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[1] It may be mentioned that one of the main points in the theory has lately received unexpected and powerful support from the brilliant discoveries of Bell and Kühne in regard to the physiology of the retina.